Sole Inventor

Docket No. 20061/OF03P111

"EXPRESS MAIL" mailing label No.
EV 309992200 US
Date of Deposit: **October 1, 2003**

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Magda Greer

Magda Greer

APPLICATION FOR UNITED STATES LETTERS PATENT

SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

Be it known that I, Wan Shick KIM, a citizen of the Republic of Korea, residing at 202-1305, Shinil Apartment, Youngduk-Ri, Kiheung-Eup, Yongin-Si, Kyunggi-Do, Republic of Korea have invented new and useful **APPARATUS AND METHODS FOR SLURRY FLOW CONTROL**, of which the following is a specification.

APPARATUS AND METHODS FOR SLURRY FLOW CONTROL

FIELD OF THE DISCLOSURE

[0001] The present disclosure relates generally to chemical mechanical polishing apparatus, and more particularly to apparatus and methods for slurry flow control.

BACKGROUND

[0002] As generally known in the art, as semiconductor devices have become more highly integrated, the size of the source/drain and the line widths of the gate electrode and the metal interconnect in MOS transistors have been narrowed. Various kinds of new processes have been proposed to produce semiconductor devices with fine line widths. One such process is the chemical mechanical polishing (CMP) process. The CMP process is a method for planarizing a surface of a certain material layer by generating a chemical reaction using slurry and applying a mechanical polishing force. The CMP process advantageously achieves polishing thickness precision and polishing uniformity for the whole substrate. Therefore, the CMP process has recently become an important process to produce a semiconductor device with fine line width.

[0003] The CMP process is performed in such a way that a circuit forming surface of a wafer is pressed against a surface of a polishing pad after a back face of the wafer has been attached to a wafer carrier. The polishing

pad is composed of polyurethane or poly tex. The hardness and density of the polishing pad are selected according to the materials constituting the surface to be polished.

[0004] During the CMP process, slurry solution for chemical planarization is injected onto the surface to be polished. Slurry may comprise various kinds of particles and solutions. For example, the particles may include cerium oxide, silica (SiO_2), alumina (Al_2O_3), or manganese oxide. Slurry can be classified according to the kinds of particles it contains. The particles have different shape, density and hardness based on their own compositions. Although the particles have the same compositions with respect to each other, the characteristics thereof can be different due to their preparation methods.

[0005] It is therefore important to accurately control slurry flow in the manner required by the corresponding CMP process. While known measuring apparatus can accurately measure flow of slurry which does not include particles, known measuring apparatus cannot accurately measure slurry which includes particles. Also, as described above, since slurries have various different characteristics based on the particles constituting the slurry, even if one kind of slurry could be measured or controlled, another kind of slurry could not be measured or controlled using the same reference.

[0006] FIG. 1 is a block diagram showing a conventional slurry supply system. The slurry supply system of FIG. 1 comprises a slurry supply unit 101, a slurry injection nozzle 103 for injecting slurry supplied from the slurry supply unit, and a flowmeter 102 mounted between the slurry supply unit 101

and the slurry injection nozzle 103. The flowmeter 102 controls the flow of slurry on the assumption that the slurry is fluid.

[0007] Conventional measuring apparatus for slurry flow are generally classified as a contact type apparatus or a non-contact type apparatus according to whether or not the apparatus comes into contact with slurry. The representative contact type apparatus is a rotameter, which has a problem in that abrasive particles in the slurry solution may possibly damage mechanical elements of the rotameter, and vice versa (that is, the abrasive particles may also be damaged or abraded by the mechanical elements of the rotameter). The resulting contaminated slurry may cause fatal defects such as a scratch on a wafer surface.

[0008] Non-contact type apparatus include a rotameter having an electromagnetic flowmeter, an ultrasonic flowmeter, a heat dissipation flow detector, a Hall effect electro transducer, and so forth. However, these devices are largely inaccurate or do not have fine control capacity. Therefore, they cannot be adapted to a CMP apparatus for fabricating a semiconductor since, in the CMP apparatus, a very small quantity of slurry should be controlled. That is to say, the electromagnetic flowmeter has a practical drawback of having so great a capacity. The ultrasonic flowmeter has a drawback of having a precondition that the slurry should be completely charged with electricity so as to operate the flowmeter. This precondition has a marked effect on the accuracy of measurement in a circulation of slurry flow. Also, the heat dissipation flow detector has a drawback in that reaction time is delayed about 15 to 25 seconds, which makes it impossible to adapt the

detector to a CMP apparatus to be operated in real-time. Finally, since the performance of the Hall effect electro transducer is abruptly changed if a metallic substance exists near the transducer, it may not be adapted to a CMP apparatus around which a metallic substance is dispersed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a block diagram showing a prior art apparatus for slurry flow control.

[0010] FIG. 2 is a block diagram showing an example apparatus for slurry flow control.

[0011] FIG. 3 illustrates a by-pass of the apparatus of FIG. 2.

[0012] FIG. 3A is a cross-sectional view of the by-pass of FIG. 3 taken along line A-A of FIG. 3.

[0013] FIG. 4 is a flow chart illustrating an example method for slurry flow control.

[0014] FIG. 5 is a block diagram illustrating another example apparatus for slurry flow control.

[0015] FIG. 6 is a flow chart illustrating another example method for slurry flow control.

DETAILED DESCRIPTION

[0016] FIG. 2 is a block diagram illustrating an example apparatus for slurry flow control. In the example of FIG. 2, the apparatus for slurry flow

control comprises a slurry supply unit 201, a slurry flow control unit 203, and a slurry measuring unit 202. A photo image sensor 202a is provided in the slurry measuring unit 202.

[0017] The slurry supply unit 201 serves to supply the slurry required for a CMP process to a slurry injection nozzle 103 through a slurry supply line 211.

[0018] The slurry measuring unit 202 is connected with a by-pass 212 diverged from the slurry supply line 211. The slurry measuring unit 202 measures the sizes of particles in the slurry flowing in the by-pass 212 and calculates the density of the slurry. The measurement of the particle sizes and the calculation of the slurry density are performed in cooperation with the photo image sensor 202a in the slurry measuring unit 202. As shown in FIGS. 3 and 3A, the photo image sensor 202a detects a generally cross-sectional image of the by-pass in which the slurry flows and displays the sizes of particles on the detected image and the particle density of the slurry solution across the cross-section of the by-pass.

[0019] The slurry flow control unit 203 receives information on the particle sizes and the slurry density obtained by the slurry measuring unit 202, checks whether or not the received information corresponds to prescribed flow information, and controls the supply flow of the slurry by regulating the slurry supply unit 201 so as to supply slurry in the proper quantity.

[0020] Meanwhile, the slurry passing through the by-pass 212 connected to the slurry measuring unit 202 is returned to the slurry supply line 211 after the particle sizes and the density of the slurry are measured. Such

construction makes it possible to periodically analyze slurry properties, and to control the slurry flow in real-time.

[0021] If diluent solution is supplied in the by-pass 212, the amount of particles and the density of the slurry in the by-pass 212 may be decreased in proportion to the amount of supplied diluent solution. Thus, the amount of particles and the density of the slurry in the slurry supply line 211 should be adjusted and calculated considering the amount of supplied diluent solution. They may be adjusted to be higher in proportion to the amount of supplied diluent solution, and in inverse proportion to the amount of supplied slurry. It is not necessary to control at the same time.

[0022] A method to control slurry flow with the apparatus of FIG. 2 will be now described. As shown in FIG. 4, slurry begins to be supplied from the slurry supply unit 201 through the slurry supply line 211 (S401).

[0023] A certain quantity of slurry is introduced into the by-pass 212 diverged from the slurry supply line 211 (S402). A cross-sectional image of the by-pass 212 is obtained (S403). For example, the cross-sectional image of the by-pass 212 may be obtained by the photo image sensor 202a described above. The sizes of the particles included in the slurry and the density of the slurry are measured using the cross-sectional image detected by the photo image sensor 202a (S404).

[0024] Information on the measured particle sizes and the density of the slurry solution is transmitted to the slurry flow control unit 203. The slurry flow control unit 203 controls the slurry supply unit 201 to supply slurry in the proper quantity (S405).

[0025] The apparatus of FIG. 2 comprises the by-pass 212 diverged from the slurry supply line 211 so that particle sizes and the density of the slurry flowing in the by-pass 212 are measured. However, if so many particles are contained in the slurry, that is, the concentration of particles relative to the solution is high, it is possible that an accurate calculation of particle size upon measurement of the cross-sectional image of the by-pass 212 using the photo image sensor 202a may be difficult.

[0026] In order to solve this problem, a second example apparatus and example method for slurry flow control will now be described. In the following examples, the cross-sectional image can be accurately measured, even when the slurry contains a high concentration of particles.

[0027] FIG. 5 is a block diagram showing an example apparatus to control slurry flow. FIG. 6 is a flow chart illustrating an example method for controlling slurry flow.

[0028] In the example of FIG. 5, in addition to the elements of the apparatus of FIG. 2, the apparatus also includes a diluent solution supply unit 204. More particularly, the example apparatus of FIG. 5 comprises a slurry supply unit 201, a slurry flow control unit 203, a slurry measuring unit 202, and a diluent solution supply unit 204. A photo image sensor 202a is provided in the slurry measuring unit 202. As with the apparatus of FIG. 2, the slurry supply unit 201 serves to supply the slurry required for a CMP process to a slurry injection nozzle 103 through a slurry supply line 211.

[0029] As in the example of FIG. 2, in the example of FIG. 5, the slurry measuring unit 202 is connected with a by-pass 212 diverged from the

slurry supply line 211. The slurry measuring unit 202 measures the sizes of the particles in the slurry flowing in the by-pass 212 and calculates the density of the slurry. The measurement of the particle size and the calculation of the density are performed in cooperation with the photo image sensor 202a in the slurry measuring unit 202. As shown in FIGS. 3 and 3A, the photo image sensor 202a captures a generally cross-sectional image of the by-pass 212 in which the slurry flows, and displays the sizes of particles in the detected image and the particle density of the slurry solution across the cross-section of the by-pass 212.

[0030] The measuring unit 202 is connected with the diluent solution supply unit 204. The diluent solution supply unit 204 is a device for supplying pure water or a solution with substantially the same composition as the slurry solution to the slurry in the by-pass 212. As the diluent solution is supplied from the diluent solution supply unit 204 to the slurry in the by-pass 212, the concentration of particles to slurry is reduced by a known amount determined by the amount of diluent solution added, so that the photo image sensor 202a can accurately measure the cross-sectional image for slurry having a high concentration of particles.

[0031] The slurry flow control unit 203 receives information on the particle sizes and the slurry density obtained by the slurry measuring unit 202, and controls the supply flow of the slurry by regulating the slurry supply unit 201 so as to supply the slurry in proper quantity.

[0032] As described in connection with the example of FIG. 2, the slurry passing through the by-pass 212 can be returned to the slurry supply

line 211 after the slurry measuring unit 202 has measured the particle sizes and the density of the slurry.

[0033] An example method to control slurry flow will be now described. In the example of FIG. 6, slurry begins to be supplied from the slurry supply unit 201 through the slurry supply line 211 (S601).

[0034] A certain quantity of the slurry is introduced into the by-pass 212 diverged from the slurry supply line 211 (S602). Then, the diluent solution is introduced into the by-pass 212 (S603). Preferably, the diluent solution is pure water or a solution with the same composition as slurry solution. The reason for inserting the diluent solution is to improve the accuracy of the cross-sectional image of the by-pass 212 using the photo image sensor 202a when the particle concentration of the slurry is high.

[0035] After the diluent solution has been introduced to the slurry flowing in the by-pass 212, a cross-sectional image of the by-pass 212 is captured (S604). The cross-sectional image of the by-pass 212 may be obtained, for example, by the photo image sensor 202a described above. The sizes of the particles included in the slurry and the density of the slurry solution are measured using the cross-sectional image detected by the photo image sensor 202a (S605).

[0036] After measuring the particle size and calculating the slurry density, the slurry in the by-pass 212 is discharged into the slurry supply line 211 so as to be forwarded toward the slurry injection nozzle 103.

[0037] Meanwhile, information on the measured particle sizes and the density of the slurry solution is transmitted to the slurry flow control unit 203.

The slurry flow control unit 203 controls the slurry supply unit 201 to supply slurry in the proper quantity (S606).

[0038] The disclosed apparatus and methods can conduct real-time flow control of slurry fed to an injection nozzle through a slurry supply line by attaching a photo image sensor for detecting a cross-sectional image of the supply line or a bypass of the supply line to one side of the slurry supply line, and by accurately calculating the sizes of the particles included in the slurry and the density of slurry using the detected image.

[0039] From the foregoing, persons of ordinary skill in the art will appreciate that an apparatus has been provided for controlling slurry flow in a chemical mechanical polishing apparatus for planarizing an object to be polished by supplying certain slurry on a grinding pad through a slurry injection nozzle. The apparatus includes: a slurry supply unit for supplying slurry to a slurry injection nozzle through a slurry supply line; a photo image sensor mounted to one side of a by-pass diverged from the slurry supply line so as to detect a cross-sectional image of the slurry flowing in the by-pass; a slurry measuring unit for analyzing the image captured by the photo image sensor so as to measure the sizes of particles included in the slurry and the density of the slurry; and a slurry flow control unit for controlling the slurry supply unit based upon information on the particle sizes and the slurry density measured by the slurry measuring unit.

[0040] Persons of ordinary skill in the art will further appreciate that an apparatus has been provided for controlling slurry flow in a chemical mechanical polishing apparatus for planarizing an object to be polished by

supplying certain slurry on a grinding pad through a slurry injection nozzle. The apparatus includes: a slurry supply unit for supplying slurry to a slurry injection nozzle through a slurry supply line; a photo image sensor mounted to one side of a by-pass diverged from the slurry supply line so as to detect a cross-sectional image of slurry flowing in the by-pass; a slurry measuring unit for analyzing the image so as to measure the sizes of particles included in the slurry and the density of the slurry; a diluent solution supply unit for supplying diluent solution in the by-pass so as to reduce the concentration of particles in the slurry so that the photo image sensor accurately detects the cross-sectional image of the by-pass; and a slurry flow control unit for controlling the slurry supply unit based upon information on the particle sizes and the slurry density measured by the slurry measuring unit.

[0041] Preferably, the diluent solution is pure water or a solution with the same composition as the slurry solution.

[0042] Persons of ordinary skill in the art will further appreciate that a method has been provided for controlling slurry flow in a chemical mechanical polishing apparatus for planarizing an object to be polished by supplying slurry on a grinding pad through a slurry injection nozzle. The disclosed method is performed by: supplying slurry to the slurry injection nozzle through a slurry supply line; introducing slurry in a by-pass diverged from the slurry supply line; detecting a cross-sectional image of the by-pass so as to measure the sizes of particles included in the slurry and the density of the slurry; and controlling the supply of slurry based upon the measured sizes of particles and density of slurry.

[0043] Persons of ordinary skill in the art will further appreciate that a method has been provided for controlling slurry flow in a chemical mechanical polishing apparatus for planarizing an object to be polished by supplying slurry on a grinding pad through a slurry injection nozzle. The disclosed method is performed by: supplying slurry to the slurry injection nozzle through a slurry supply line; introducing slurry into a by-pass diverged from the slurry supply line; supplying a diluent solution into the by-pass so as to reduce a concentration of particles of slurry; detecting a cross-sectional image of the by-pass so as to measure the sizes of particles included in the slurry and the density of the slurry; and controlling supply of slurry based upon the measured sizes of particles and density of slurry.

[0044] Although certain example methods and apparatus have been described herein, the scope of coverage of this patent is not limited thereto. On the contrary, this patent covers all methods, apparatus and articles of manufacture fairly falling within the scope of the appended claims either literally or under the doctrine of equivalents.